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Multi-disciplinary optimization of organic Rankine cycle power systems

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The organic Rankine cycle technology is an efficient way of converting the low grade heat, from renewable energy or industrial waste, into electricity. This technology is expected to play a substantial role in the future energy generation system, as it will contribute to extend the use of renewable resources and increase the energy efficiency of industrial processes and transport, thus reducing the CO_2 emissions and the consumption of fossil fuels.

Although the ORC technology is currently used in geothermal and biomass plants, and in industrial waste heat recovery, it faces a number of challenges that hinder its expansion to a wider number of applications. For instance, highly variable heat sources such as in the case of internal combustion engines may require an improved control strategy that can handle the transients during operation. Also, recent regulations that limit the use of working fluids with high global warming potential impose the search of alternative fluids that meet both thermodynamic and environmental requirements. Furthermore, the technology needs to be more competitive by increasing the energy conversion efficiency and reducing the volume to power ratio.

Here we aim at presenting the work carried out at our group, where an interdisciplinary approach, with both experimental and numerical research, is followed to overcome the current challenges of the organic Rankine cycle technology. The project DYNCON-ORC aims at developing a predictive control strategy for mini-scale units to be used in heavy-duty vehicles. The project NanoORC aims at developing models for the prediction of the thermophysical and transport properties of innovative working fluids. A H.C.-Ørsted project investigates experimentally the heat transfer of zeotropic mixtures in plate heat exchangers to contribute to the design of more efficient organic Rankine cycle units. Finally, the project MicroPHE focuses on the numerical optimization of microstructure enhanced plate heat exchangers in order to reduce the heat transfer equipment costs.

The on-going and future work developed within these projects, supported all by European funding, will provide essential knowledge to the scientific and industrial communities, and will contribute to build a sustainable future based on an efficient and clean exploitation of the energy resources.

Multi-disciplinary optimization of organic Rankine cycle power systems

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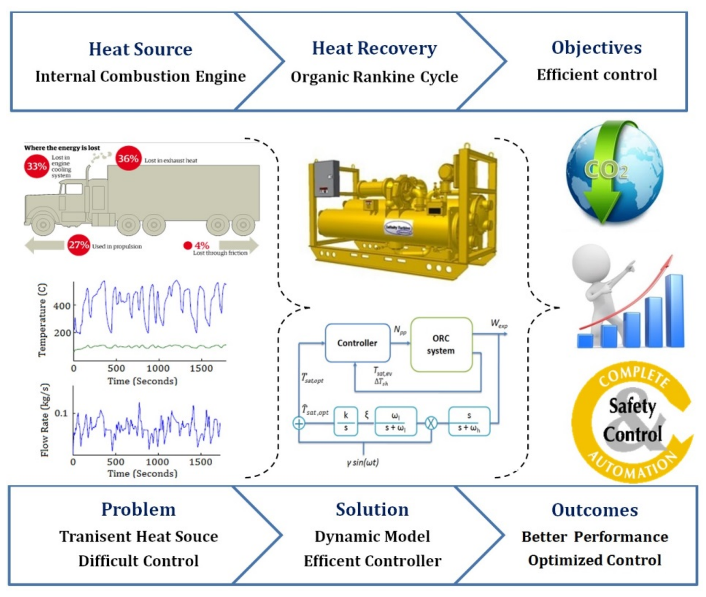
The organic Rankine cycle technology

Organic Rankine cycle (ORC) power systems are thermodynamic cycles that convert low-temperature heat into power by evaporating organic fluids which flow through an expander coupled to a generator. ORC units can produce power from renewable energy resources and waste heat sources, and have gained worldwide acceptance as they are expected to play a substantial role in the future fossil-free energy system.

ORC unit installed on board a container ship.

Project DYNCON-ORC: dynamic predictive control

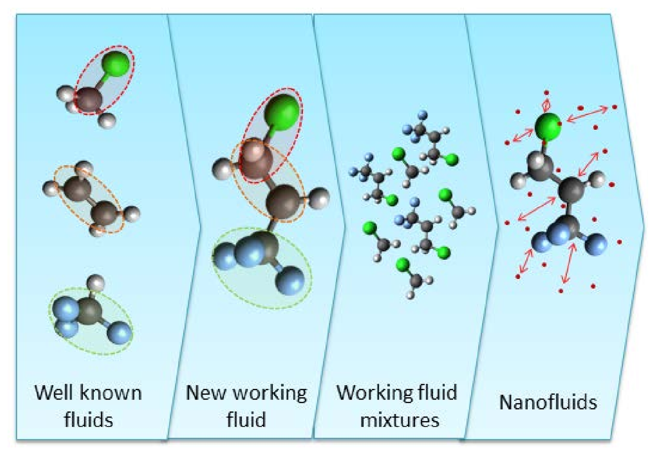
The primary goal of this project is to control a mini-scale ORC unit for waste heat recovery from internal combustion engines of heavy duty vehicles in an efficient and optimized manner.

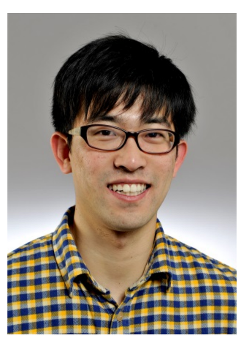


Project NanoORC: innovative working fluids

The project aims at developing models for the prediction of the thermophysical and transport properties of innovative working fluids.

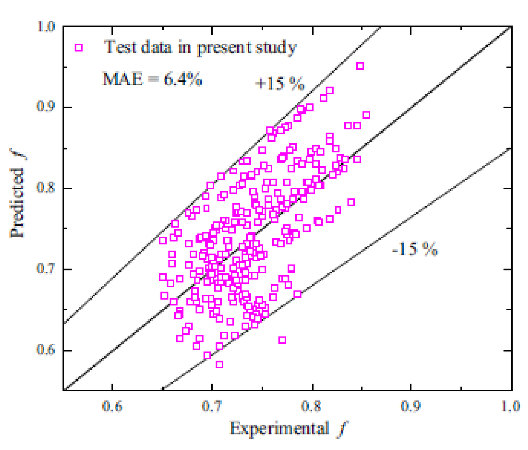
Models are developed for pure substances and mixtures. The impact of the addition of nanoparticles is investigated.



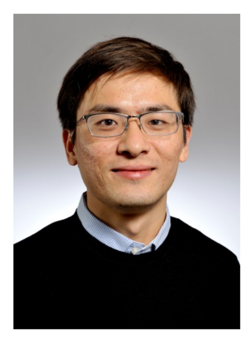


HC Ørsted project: experimentation on zeotropic mixtures

The project investigates experimentally the heat transfer of zeotropic mixtures in plate heat exchangers to contribute to the design of more efficient organic Rankine cycle units.

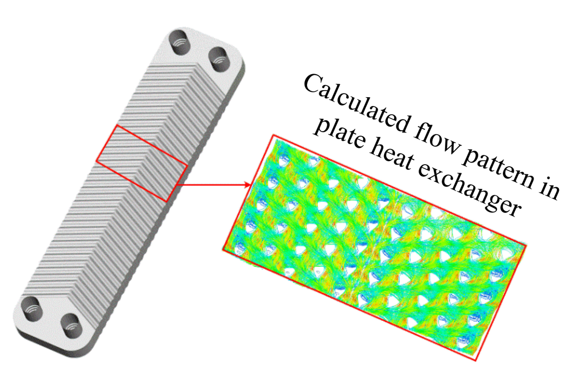


A new correlation for high temperature flow boiling in ORC evaporators has been developed using experimental data. The correlation outperforms the existing correlations for heat transfer.



Project MicroPHE: microstructure plate heat exchangers

The project focuses on the numerical study and design of microstructure enhanced plate heat exchangers. Numerical models will be developed to predict the heat exchanger thermal-hydraulic performance.



The ultimate goal of this project is to provide a methodology that can be used to design high performance and economic plate heat exchangers for ORC system applications.

Acknowledgements

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